Clearinghouse of Technologies for Reducing Non-CO_2 Greenhouse Gas Emissions

(CARB 05-328)

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Background

- California is vulnerable to the impacts of climate change.
- Non-CO_2 greenhouse gases (NCGGs) emissions in CA were 75 $MMT_{CO2\text{-}Eq.}$ in 2004.
- NCGGs = ~18% of total GHG emissions
  - Nitrous oxide (7.6%)
  - Methane (6.4%)
  - HFCs, PFCs, and SF_6 (3.2%)

Background

- Climate mitigation studies have been focused on CO_2, especially energy-related sources.
- NCGGs have gained attention recently
  - Higher global warming potentials (GWPs)
  - Abundance of cost-effective and readily-implementable technological options
  - A more rapid response in avoiding climate impacts by focusing on short-lived gases

Project Objectives

- To develop a clearinghouse of technological options for reducing anthropogenic, NCGG emissions from sectors that are relevant to CA.
- To provide better characterization of cost-effective opportunities for emission reductions of NCGGs from all sectors.
- The findings can serve as a basis for a website to disseminate information on NCGG emission control technologies.
- (Black carbon was also included in this study).

Project Tasks

- Identification of sources of NCGG emissions from various sectors in California
- Identification of available technological options for NCGG emission reductions through a comprehensive literature search
- Evaluation of the identified technological options for their applicability in CA
- Report preparation

Methods and Approaches – Identify Sources of NCGG Emissions

- Conduct a literature review on GHG emissions.
- Focus on identifying key sources of NCGG emissions from various sectors.
- Include the work done worldwide.
- Assess the existence and importance of these sources in CA.

Methods and Approaches – Literature Search

- The search typically started in *Compendex* and was repeated in *Environmental Abstracts*, then *Web of Science*, and finally *ScienceDirect*.
- Internet search engines (e.g., Google.com) were used to find websites that are relevant to NCGG gases. A handful of websites were identified.
- A few key national and international conferences were also identified.

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Air Resources Board

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Climate Change

This page updated March 20, 2006.

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About ARB

Programs

What's New

Board Meetings:
- Future
- Past

Calendar

This page provides links to information concerning climate change including Assembly Bill 1493 (Pavley) signed by the Governor on July 22, 2002.

- What's New?
- Fact Sheets
- Workshops and Meetings

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Calif. Air Resources Board
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Climate Change Research
Climate Change Advisory Committee
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ANNOUNCEMENTS
February 9, 2006
PIER Informal Presentation
New Developments in Macroeconomic Modeling using CGE Models for Climate Change Studies
http://www.climatechange.ca.gov/climate_action_team/reports/index.html
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US EPA - Non-CO2 Gases Economic Analysis and Inventory: Projections and Mitigation Costs - Microsoft Internet Explorer

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U.S. Environmental Protection Agency

Non-CO2 Gases Economic Analysis and Inventory

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EPA Home > Global Warming Home > Non-CO2 Gases Economic Analysis and Inventory > Projections & Mitigation Costs

Global Warming Home

Non-CO2 Gases Economic Analysis & Inventory Home

Sources & Emissions

Projections & Mitigation Costs

International Analyses

Links & Resources

Projections and Mitigation Costs

EPA collects and analyzes data on future emissions of non-CO_2 greenhouse gases, technological options for reducing these emissions, and the costs associated with emission reductions. These analyses have two objectives.

- First, they present EPA's baseline forecast of non-CO_2 greenhouse gas emissions from the major human-related sources in the U.S. and worldwide, as well as EPA's cost estimates of reducing these emissions.
- Second, these analyses provide a transparent methodology for the calculation of emission estimates and reduction costs, thereby enabling other analysts to replicate these results or use the approaches described herein to conduct similar analyses in other countries or for

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IIASA - Greenhouse Gas Initiative - Microsoft Internet Explorer

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Science for Global Insight

IIASA About IIASA Research Events & Outreach Publications Search

Greenhouse Gas Initiative

The Greenhouse Gas Initiative is a inter-project research activity that addresses questions critical to understanding and responding to the challenges of climate change.

It is a joint Initiative, with activities reaching across seven IIASA programs: Environmentally Compatible Energy Strategies, Forestry, Land Use Change Program, World Population Program, Risk and Vulnerability (RAV) Program (former Risk, Modeling and Society Program, RMS), Atmospheric Pollution and Economic Development (APD) (former Transboundary Air Pollution Program), and the Transitions to New Technologies Program.

Principal research activities include the development of long-term, global scenarios; the assessment of near- to medium-term mitigation and adaptation opportunities for specific countries; and the development of an integrated modeling framework to analyze international policy approaches. Analysis encompasses multiple gases and sectors (energy, agriculture, forestry), and the initial focus on emissions mitigation will be expanded to include climate change

Greenhouse Gas Initiative Homepage

Research

Research Plan 2004

Models

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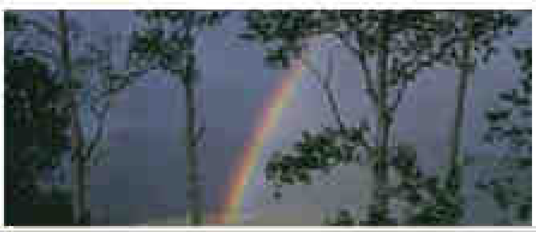

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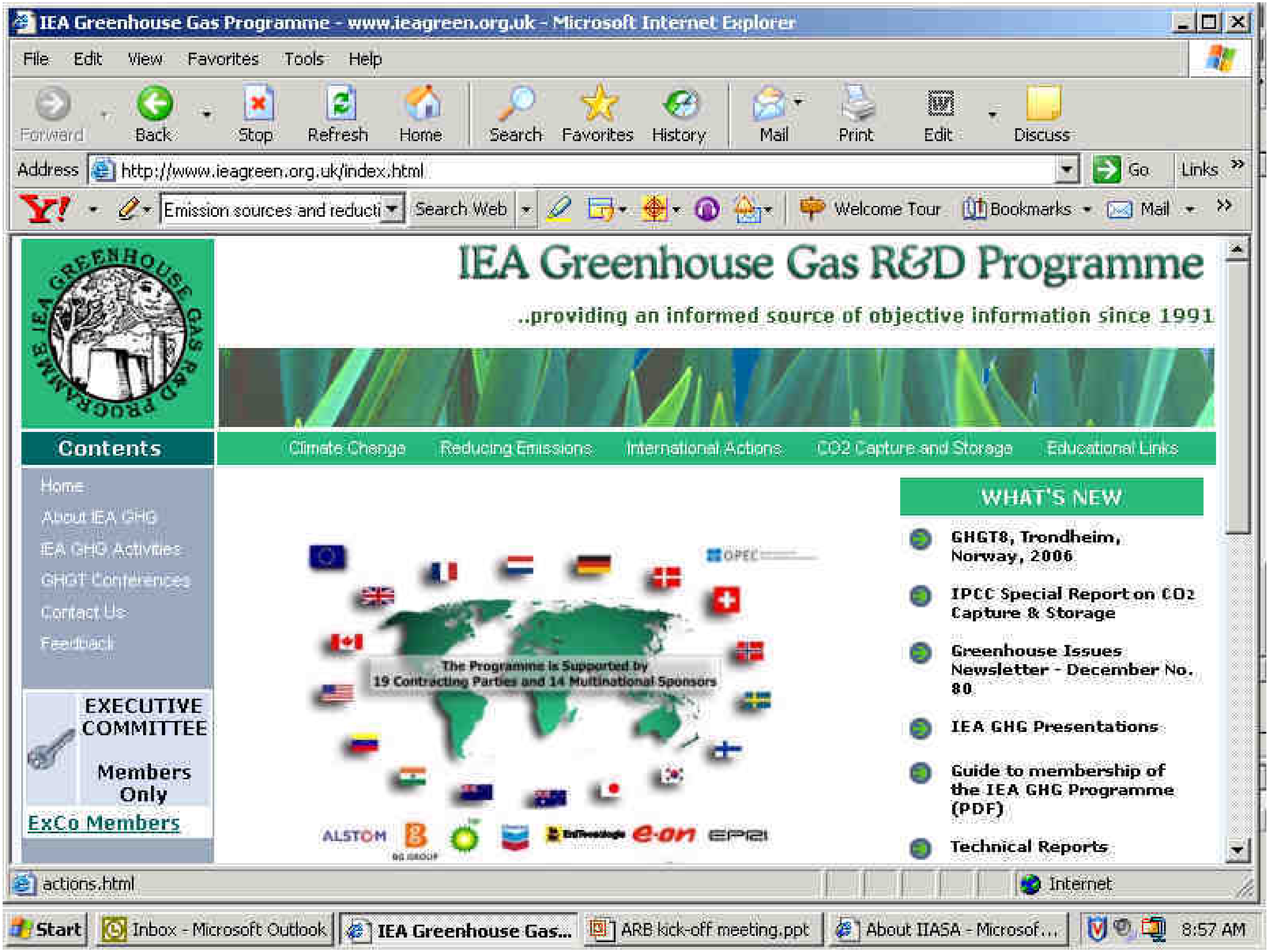
IEA Greenhouse Gas Programme - www.ieagreen.org.uk - Microsoft Internet Explorer
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IEA GHG Activities
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The Programme is Supported by
19 Contracting Parties and 14 Multinational Sponsors
OPEC
ALSTOM
e-on
EPRI
WHAT'S NEW
GHGT8, Trondheim, Norway, 2006
IPCC Special Report on CO2 Capture & Storage
Greenhouse Issues Newsletter - December No. 80
IEA GHG Presentations
Guide to membership of the IEA GHG Programme (PDF)
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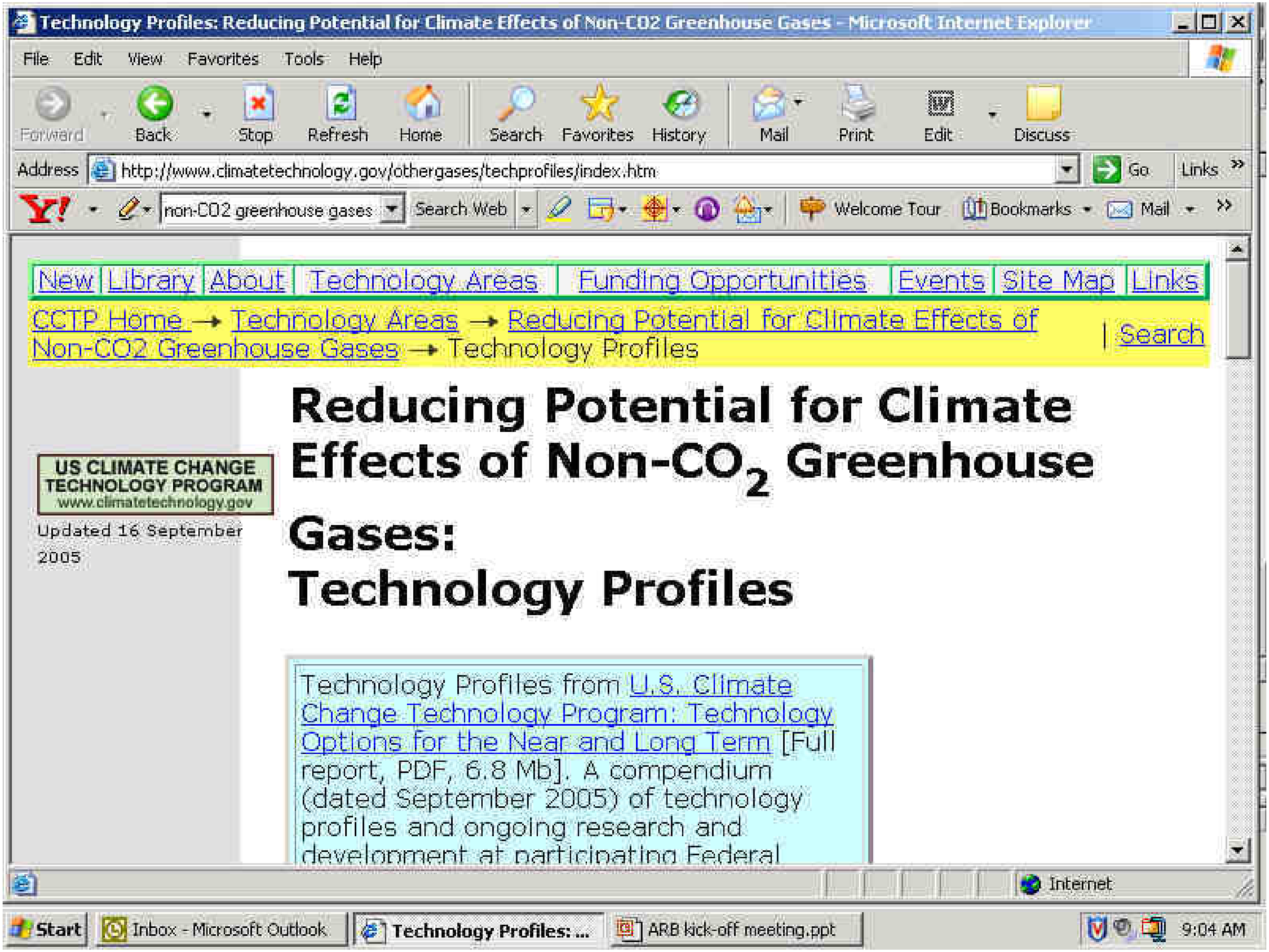
Technology Profiles: Reducing Potential for Climate Effects of Non-CO2 Greenhouse Gases - Microsoft Internet Explorer
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US CLIMATE CHANGE TECHNOLOGY PROGRAM
www.climatetechnology.gov
Updated 16 September 2005
Reducing Potential for Climate Effects of Non-CO2 Greenhouse Gases:
Technology Profiles
Technology Profiles from U.S. Climate Change Technology Program: Technology Options for the Near and Long Term [Full report, PDF, 6.8 Mb]. A compendium (dated September 2005) of technology profiles and ongoing research and development at participating Federal
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Climate Change 2001:
Mitigation

3.5.6 Conclusions

It once again becomes clear that enhanced energy efficiency improvement remains the main option for emission reduction in the manufacturing industry. There are substantial differences in the level of energy efficiency between countries and also potentials differ. For most OECD countries and for a number of developing countries extended inventories of emission reduction options in industry exist. However, the focus is still very much on the heavy industrial sector. The total potential of energy efficiency improvement for the year 2010 can be estimated to be 300–500MtC for the year 2010. It seems possible to develop new technologies to sustain energy efficiency improvement in the longer term; if such innovations materialize the potential can be 700 – 900MtC for the year 2020. The larger part of these emission reductions can be attained at net negative costs.

A category of options to which only limited attention was paid in relation to greenhouse gas emission reduction is material efficiency improvement. It is clear that substantial technical potentials exist. These may be sufficient to attain emission reductions on the order of 600MtC in the year 2020 (UN, 1997). However, a significant effort is needed in selection,


http://www.greenhouse.crc.org.au/Research/f.cfm
Cooperative Research Centre
for Greenhouse Accounting
Home > Research > f
Non-CO_2 greenhouse gases
(Program F)
Program leader: Dr Richard Eckard
The Non-carbon-dioxide (CO_2) greenhouse gases program is developing best management practices to reduce emissions of the greenhouse gases methane and nitrous oxide in the dairy, grains and cotton farming industries.
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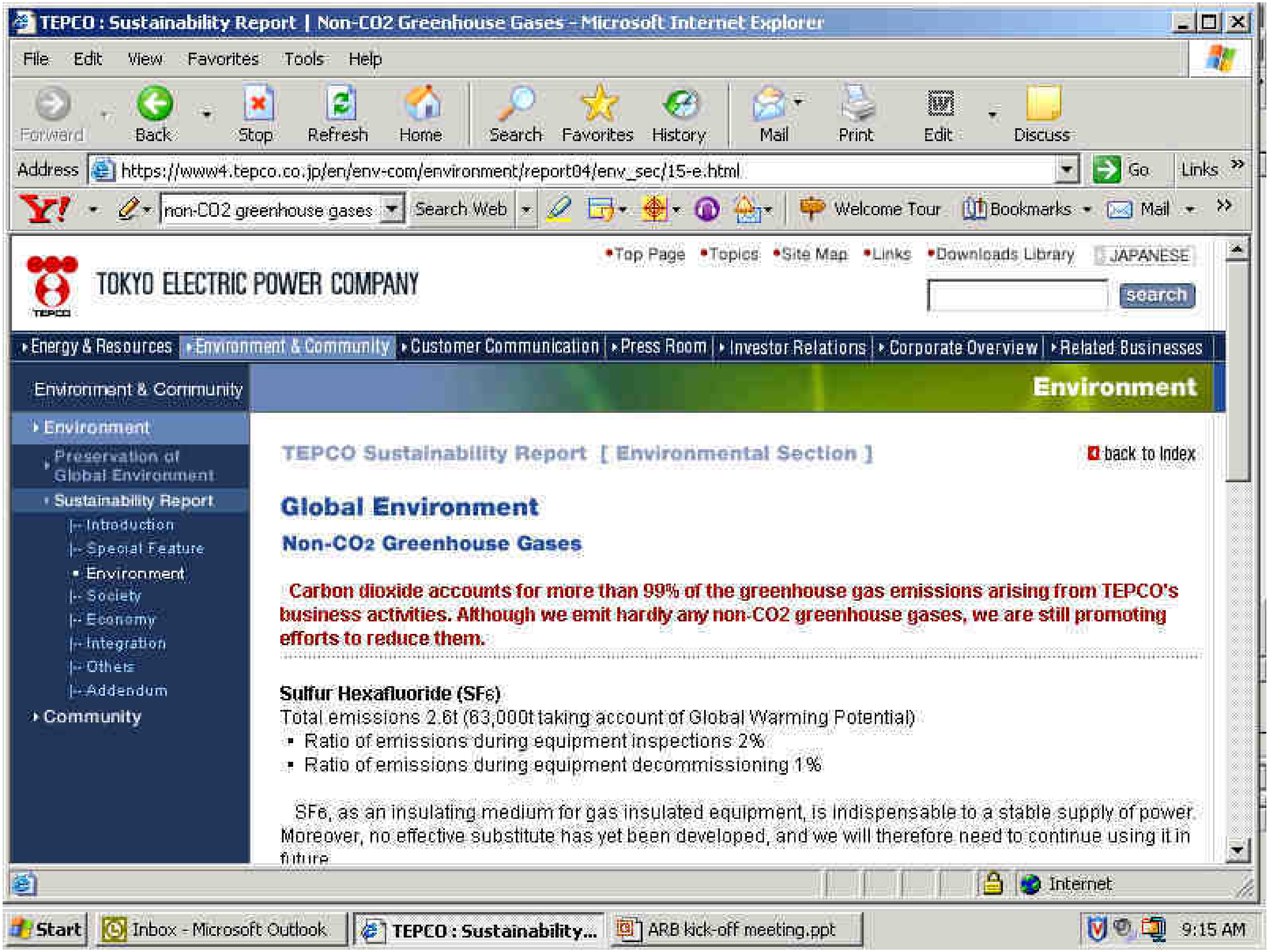

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Environment & Community

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Environment

TEPCO Sustainability Report [Environmental Section]

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Global Environment

Non-CO_2 Greenhouse Gases

Carbon dioxide accounts for more than 99% of the greenhouse gas emissions arising from TEPCO's business activities. Although we emit hardly any non-CO2 greenhouse gases, we are still promoting efforts to reduce them.

Sulfur Hexafluoride (SF_6)

Total emissions 2.6t (63,000t taking account of Global Warming Potential)

- Ratio of emissions during equipment inspections 2%
- Ratio of emissions during equipment decommissioning 1%

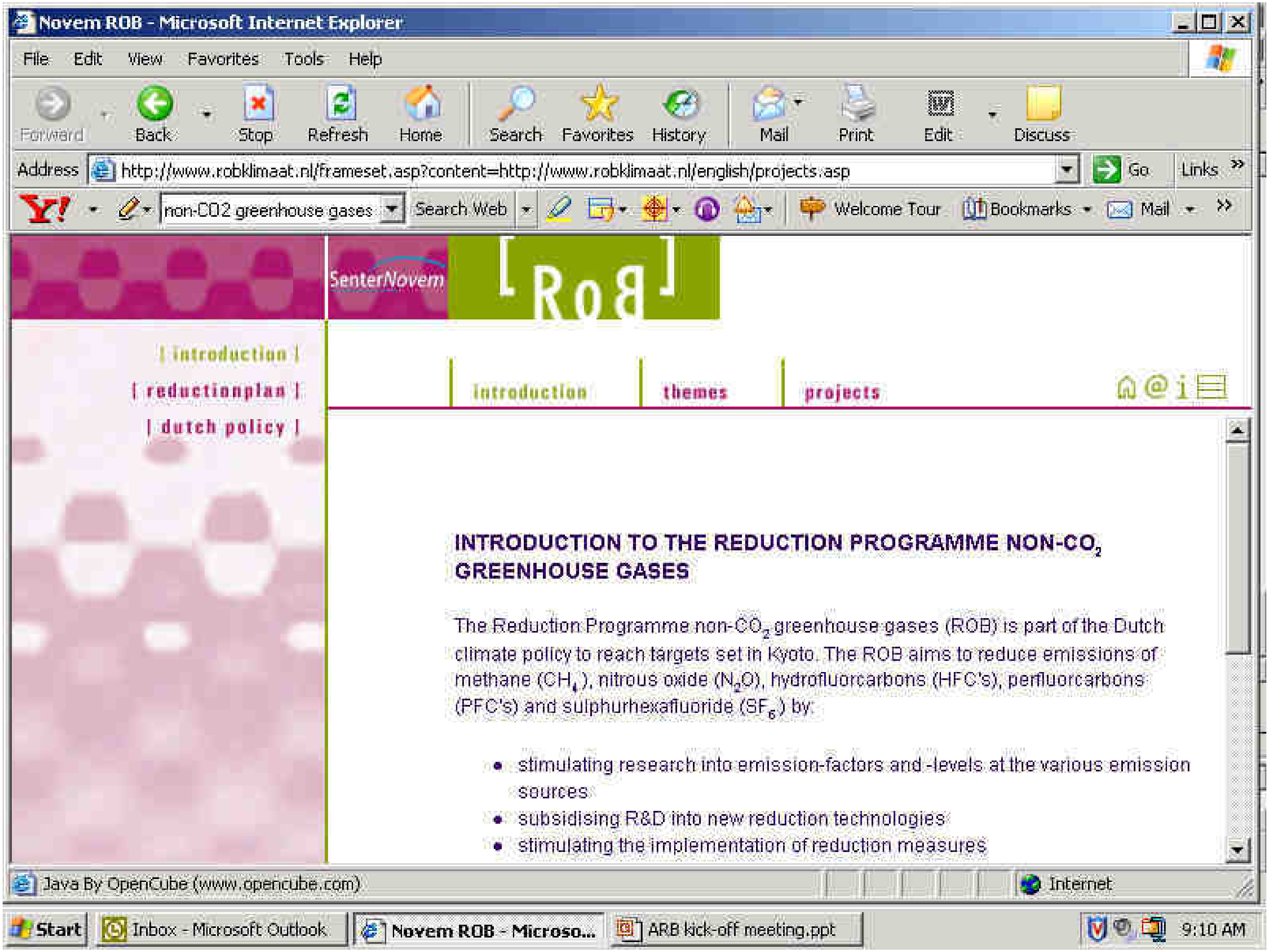
SF_6, as an insulating medium for gas insulated equipment, is indispensable to a stable supply of power. Moreover, no effective substitute has yet been developed, and we will therefore need to continue using it in future.

Non-CO_2 greenhouse gas emissions from boilers and industrial processes

Evaluation and update of emission factors for the Finnish national greenhouse gas inventory

Eemeli Tsupari, Suvi Monni & Riitta Pipatti

VTT Processes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INTRODUCTION TO THE REDUCTION PROGRAMME NON-CO_2 GREENHOUSE GASES
The Reduction Programme non-CO_2 greenhouse gases (ROB) is part of the Dutch climate policy to reach targets set in Kyoto. The ROB aims to reduce emissions of methane (CH_4), nitrous oxide (N_2O), hydrofluorcarbons (HFC's), perfluorcarbons (PFC's) and sulphurhexafluoride (SF_6) by:
• stimulating research into emission-factors and -levels at the various emission sources
• subsidising R&D into new reduction technologies
• stimulating the implementation of reduction measures
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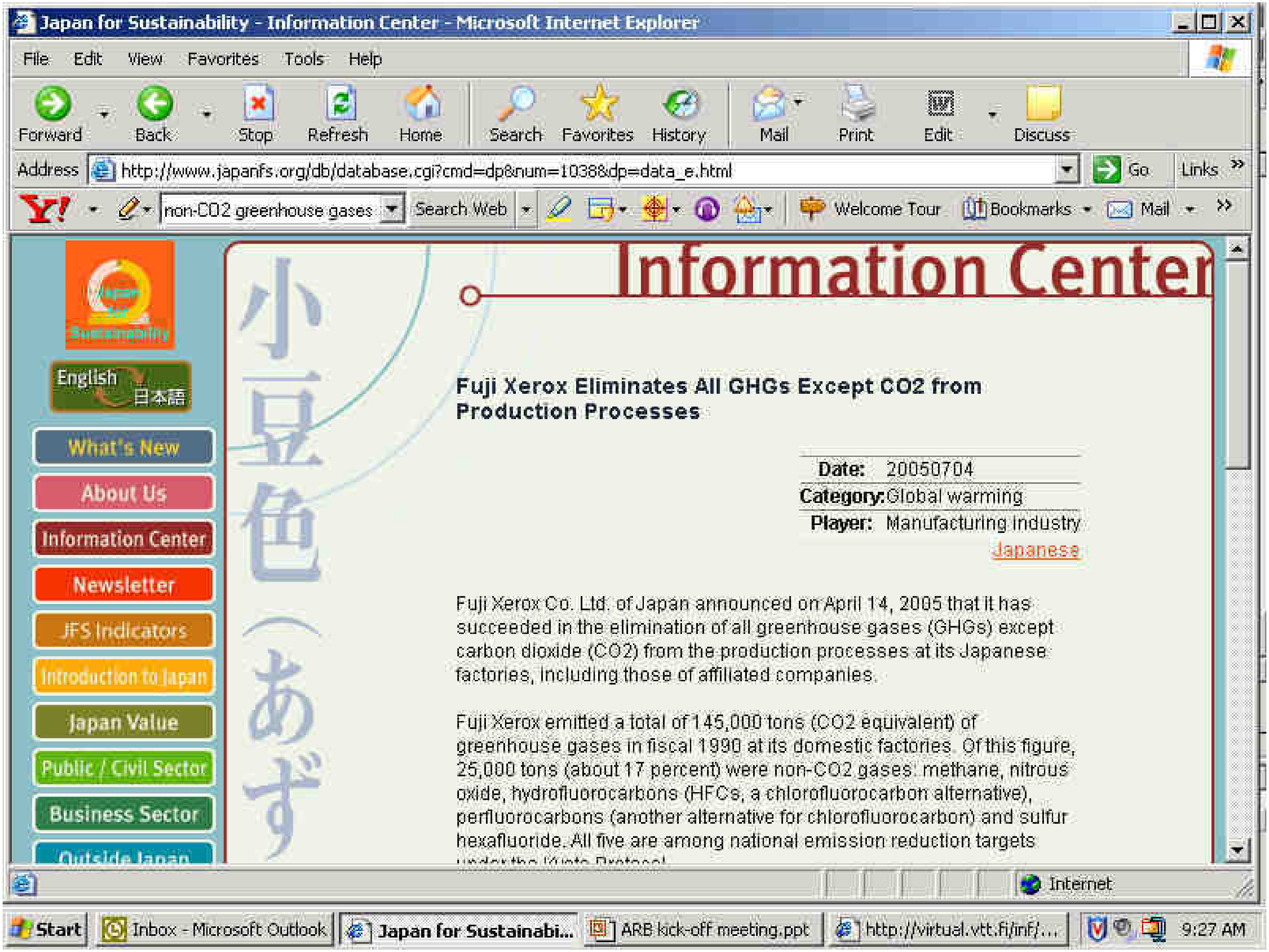
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Japan Value
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Business Sector
Outside Japan
小豆色（あずき
Fuji Xerox Eliminates All GHGs Except CO2 from Production Processes
Date: 20050704
Category: Global warming
Player: Manufacturing industry
Japanese
Fuji Xerox Co. Ltd. of Japan announced on April 14, 2005 that it has succeeded in the elimination of all greenhouse gases (GHGs) except carbon dioxide (CO2) from the production processes at its Japanese factories, including those of affiliated companies.
Fuji Xerox emitted a total of 145,000 tons (CO2 equivalent) of greenhouse gases in fiscal 1990 at its domestic factories. Of this figure, 25,000 tons (about 17 percent) were non-CO2 gases: methane, nitrous oxide, hydrofluorocarbons (HFCs, a chlorofluorocarbon alternative), perfluorocarbons (another alternative for chlorofluorocarbon) and sulfur hexafluoride. All five are among national emission reduction targets
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MillPress - Non-CO2 Greenhouse Gases: Scientific Understanding Control Options and Policy Aspec - Microsoft Internet Explorer

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Non-CO2 Greenhouse Gases: Scientific Understanding Control Options and Policy Aspects

Proceedings of the 3rd International Symposium NCGG-3, Maastricht, Netherlands, January 21-23, 2002

van Ham, J., A.P.M. Baede, R. Guicherit & J.G.F.M. Williams-Jacobse - 2002

17 x 24 cm, Hardbound, 740 pages, isbn: 90-77017-70-4

Table of Contents

ORDER ONLINE

Price: € 125

This book is arranged according to three themes and subdivided primarily into chapters which address the NCGGs methane, nitrous oxide and the fluorinated gases.

The first theme concerns new results on the sources and sinks of the NCGGs and their application in emission inventories. The second theme regards the progress in agricultural and technological options for control of emissions of NCGGs and the costs of such technologies. The third theme includes direct policy related issues such as the uncertainties in emission inventories and their verification, policy developments with respect to NCGGs, by national

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Methods and Approaches – Comparison of GHG Emissions

	USA (2004)		CA (2004)		
Gas	**$MMT_{CO2\text{-}Eq.}$**	**(%)**	**$MMT_{CO2\text{-}Eq.}$**	**(%)**	**CA/USA**
Carbon Dioxide	5,988	84.6%	364	82.8%	**6.1%**
Methane	557	7.9%	28	6.4%	**5.0%**
Nitrous Oxide	387	5.5%	33	7.6%	**8.6%**
HFCs, PFCs, SF_6	143	2.0%	14	3.2%	**9.9%**
Total	**7,074**	100%	**439**	100%	**6.2%**

Methods and Approaches – Sectors for Emission Sources

- Six source sectors, as defined by United Nations Intergovernmental Panel on Climate Change (IPCC), were used:
  1. Energy
  2. Industrial processes
  3. Solvent use
  4. Agriculture
  5. Land-use change and forestry
  6. Waste

Methods and Approaches – Source Sectors for Each NCGG in CA

	CH_4	N_2O	High GWP Gases	Black Carbon
Energy	√	√		√
Industrial processes		√	√	√
Solvent use	√	√		
Agriculture	√	√		
Land-use change and forestry	√	√		
Waste	√	√		

Methods and Approaches – Evaluation of Technological Options

- Status of technological options are quite different.
- Data on reduction efficiency (RE), market penetration (MP), technical applicability (TA), service lifetime, and costs were collected, if available, and presented.
- Data specific to CA were used first, followed by those specific to the USA, and then those developed for global perspectives or for other countries.

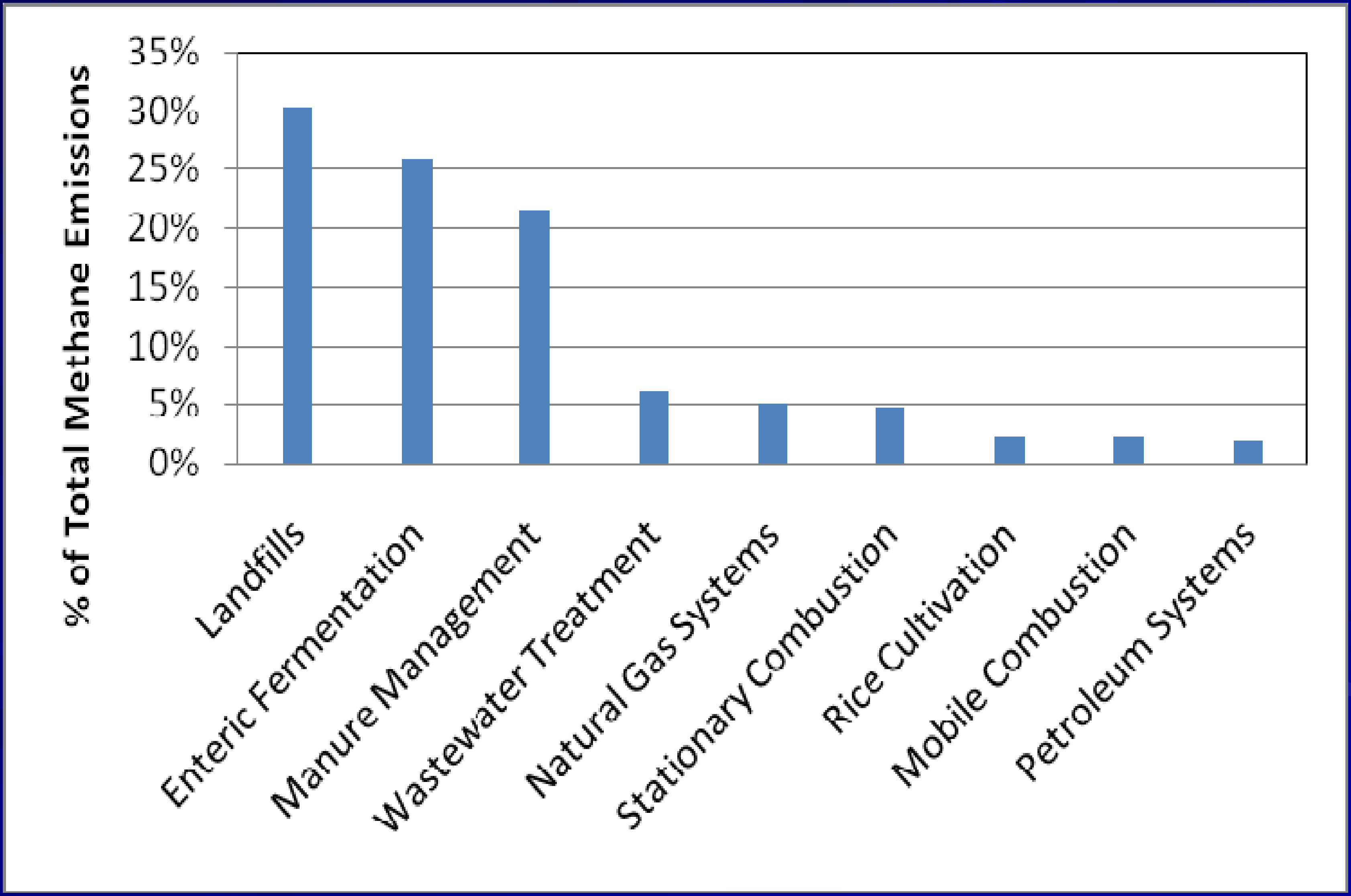
Methods and Approaches – Evaluation of Technological Options

Technology	Lifetime (yrs)	MP (%)	RE (%)	TA (%)	Capital cost	Annual cost	Benefits
Installation of plunger lift systems in gas wells[1]	10	100	4	1	$3,986	$159	$8.21
Surge vessels for station/well venting[1]	10	100	50	<1	$11,216	$224	$8.53
Replace high-bleed with low-bleed pneumatic devices[1]	5	50	86	8	$14	$0	$8.21

MP: market penetration; RE: reduction efficiency; TA: technical applicability; costs are in year 2000 US$/MT$_{CO2\text{-}Eq.}$

1: USEPA (2004) & CEC (2005); 2: IEA (2003) & USEPA (2004)

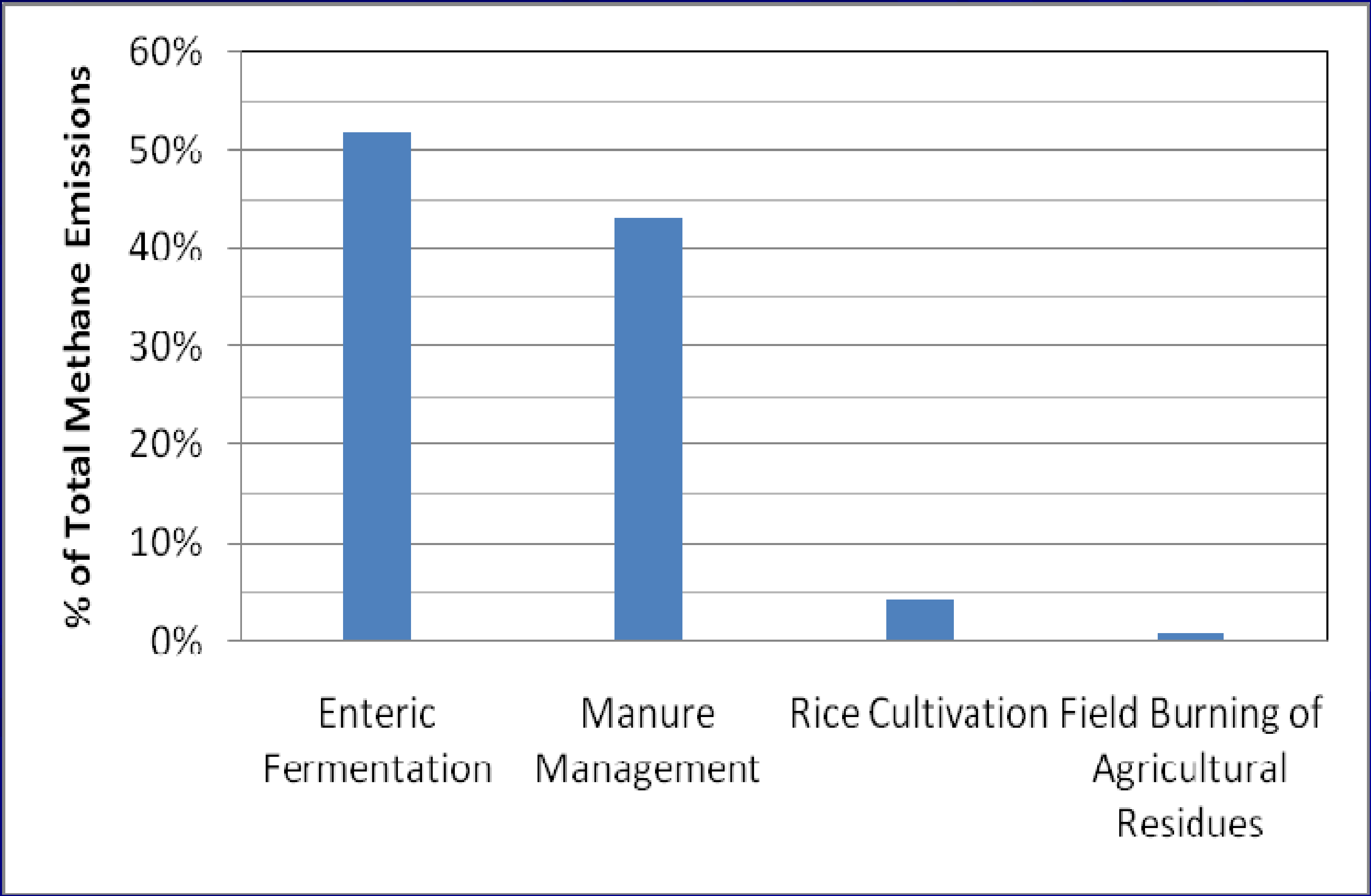
Sources of Methane Emissions in CA



Methane Emission Reduction – Gas and Petroleum Systems

- Prevention – improved process efficiencies and leakage reduction
- Recovery and re-injection – recovery of off-gases and re-injection into the subsystems
- Recovery and utilization – recovery and utilization for energy production
- Recovery and incineration – recovery, followed by incineration (flaring)
- (Many in EPA Natural Gas STAR program)

Sources of Methane Emissions from Agriculture Sector in CA



Methane Emission Reduction – Enteric Fermentation

- Increase of feed conversion efficiency by adjusting animal diets
- Increase of animal production through the use of growth hormones
- Increase of animal production by improved genetic characteristics
- Improve nutrition through strategic supplementation
- Improved reproduction

Methane Emission Reduction – Manure Management

- Livestock reduction
- Prevention of anaerobic decomposition of manure during stabling of livestock
- Anaerobic digestion (covered lagoons; on-farm mesophilic digestion; on-farm thermophilic; centralized, off-farm mesophilic or thermophilic)
- Composting of animal manure
- Aerobic digestion

Methane Emission Reduction – Rice Field

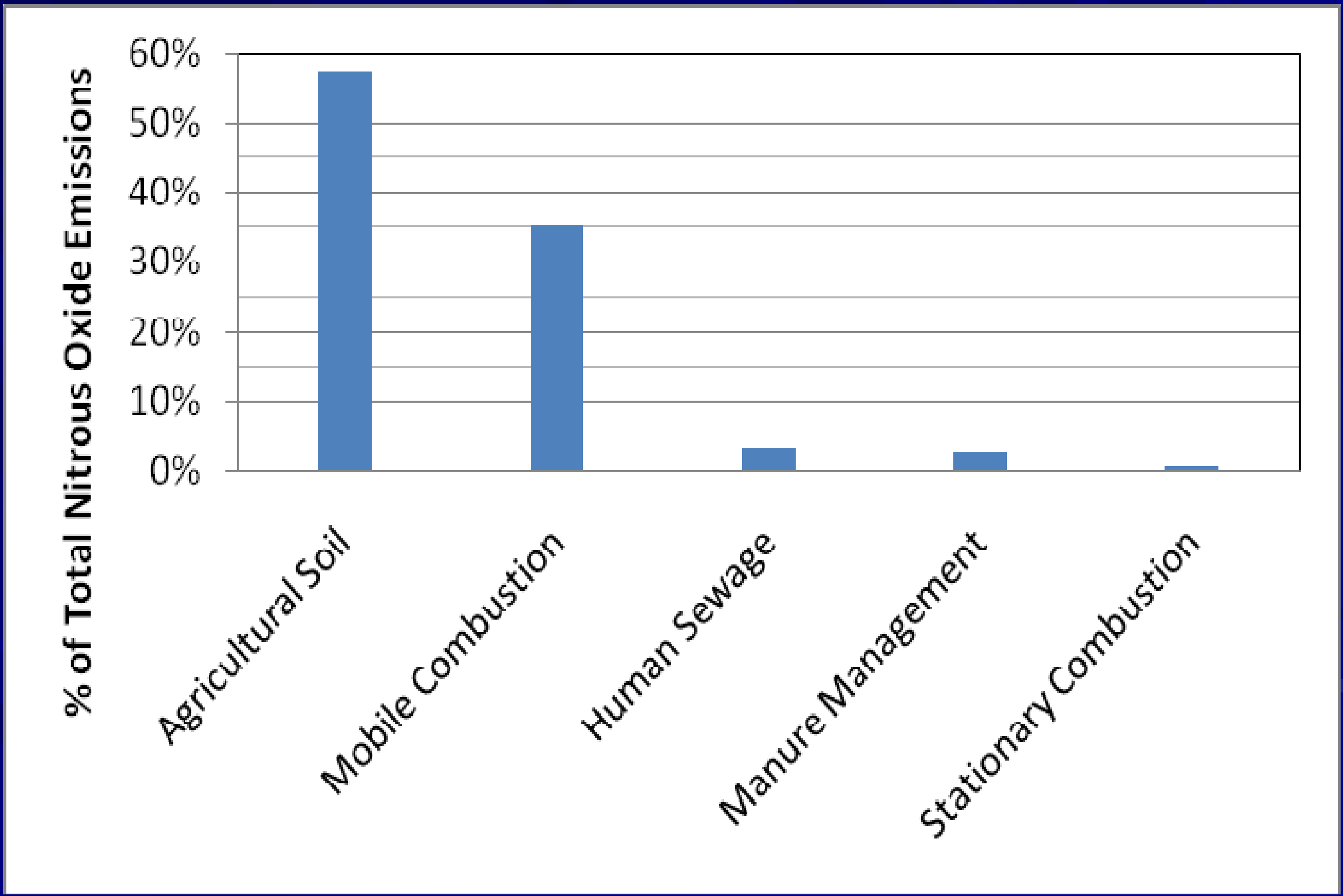
- Water management
- Shallow flooding
- Upland rice

- Alter the amendments to soils
- Use of alternative fertilizers
- Off-season straw

Methane Emission Reduction – Landfill

- Landfill gas recovery and utilization
- Anaerobic digestion
- Composting
- Mechanical biological treatment
- Increased oxidation
- Waste treatment in bioreactors
- Aerobic landfilling or aerobic pretreatment
- Source reduction

Sources of N_2O Emissions in CA



N_2O Emissions from the Agriculture Sector

	USA (2004)		CA (2004)		
Source	**$MMT_{CO2\text{-}Eq.}$**	**(%)**	**$MMT_{CO2\text{-}Eq.}$**	**(%)**	**CA/USA**
Agricultural Soil Management	261.5	93.5%	19.16	95.2%	7.3%
Manure Management	17.7	6.3%	0.89	4.4%	5.0%
Field Burning of Agricultural Residues	0.5	0.2%	0.07	0.3%	14.0%
Total	**279.7**	100%	**20.12**	100%	**7.2%**

N_2O Emission Reduction – Agricultural Soil Management

- Most of the N_2O emissions from agricultural activities are from soils, but the emission flux of N_2O per unit surface area of soil is small.
- Two types of technological options:
  - Improve efficiencies in nitrogen utilization
  - Inhibit the formation of nitrous oxide

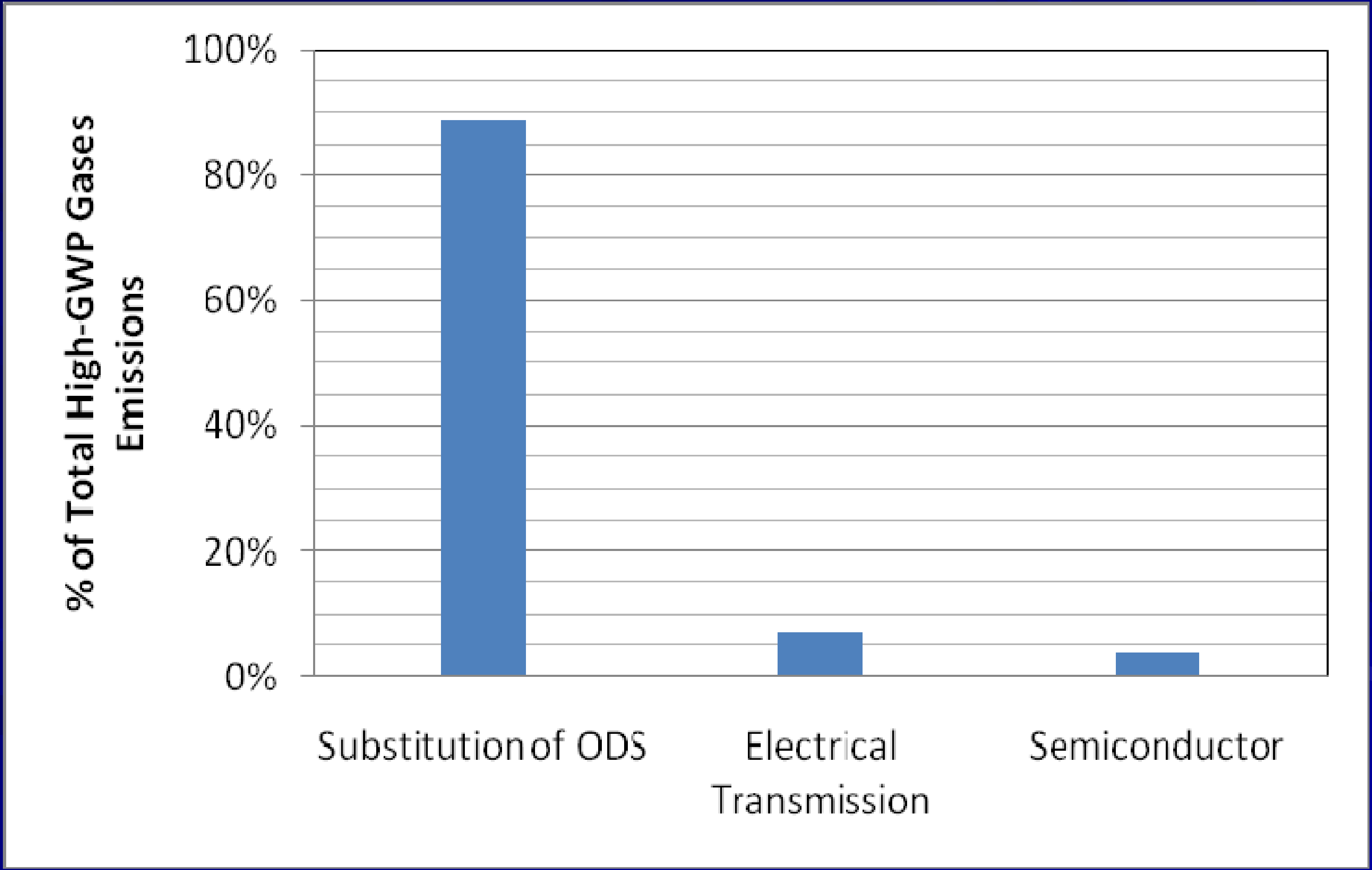
N_2O Emission Reduction – Manure Management

- Reducing the number of animals by increasing their productivity
- Optimizing the crude protein/energy ratio in animal diets
- Nitrification and urease inhibitors
- Waste storage
- Use of cattle feed-pads during winter months
- Optimizing manure management

N_2O Emission Reduction – Mobile Combustion

- Improve catalyst performance
- Use of N_2O-decomposition catalyst
- Use of alternative technologies for NO_x-emission reduction
- Alternative fuel

Sources of High-GWP Gases Emissions in CA



High-GWP Gases Emission Reduction – Substitution of Ozone-depleting Substances

- Refrigeration and air conditioning equipment
- Solvents
- Foam production
- Sterilization
- Fire extinguishing
- Technical aerosols

High-GWP Gases Emission Reduction – Foam Production

- Alternative blowing agents
- Lower-GWP HFC substitution
- Alternative insulation materials and technologies
- Direct emission reduction

High-GWP Gases Emission Reduction – Technical Aerosols

- Substitution with lower-GWP HFCs
- Not-in-kind (NIK) alternatives
- Hydrocarbon aerosol propellants
- Compressed gases

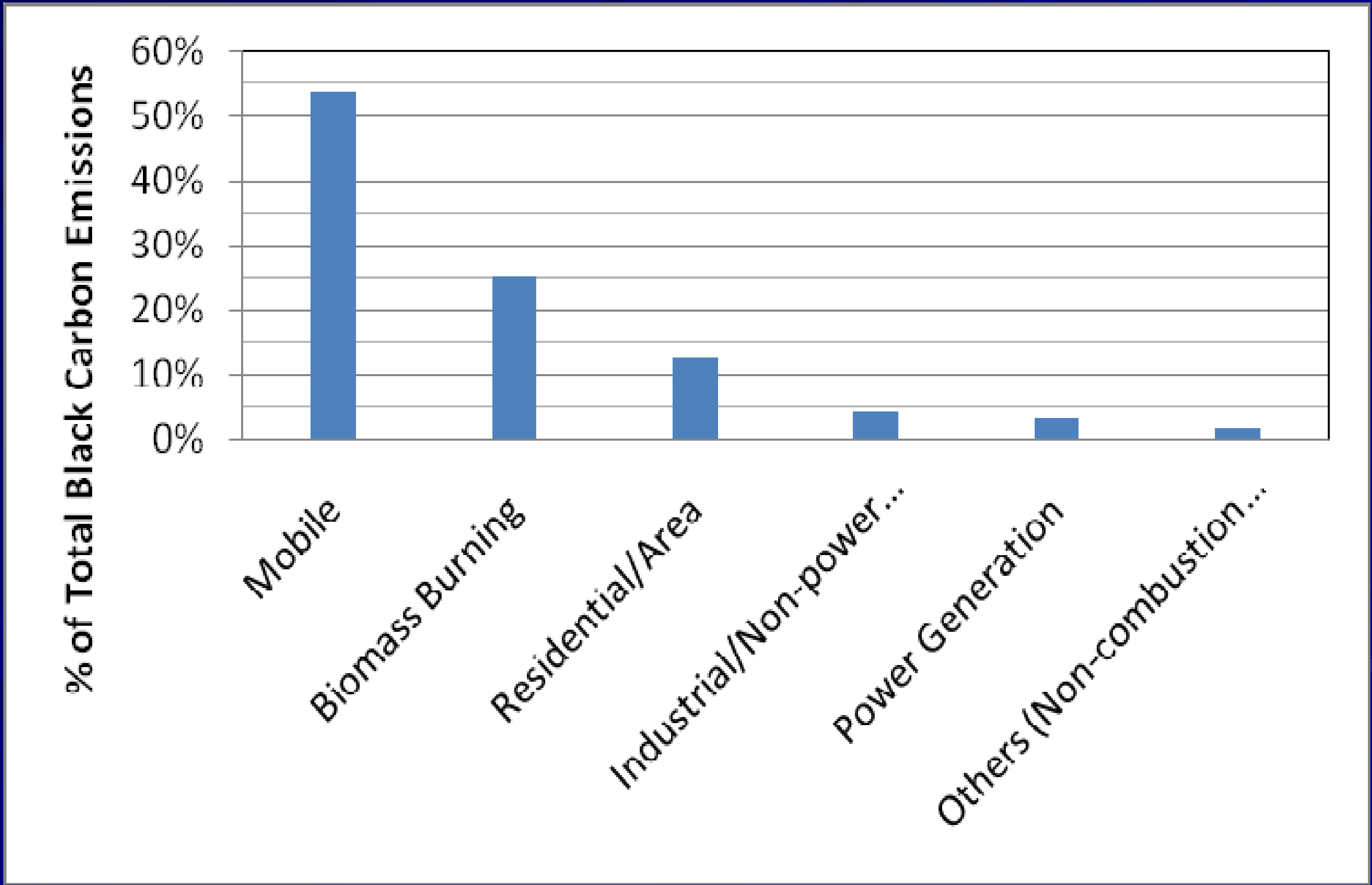
High-GWP Gases Emission Reduction – Electrical Transmission and Distribution

- Use of recycling equipment
- Leak detection and repair (LDAR)
- Equipment replacement/refurbishment
- Others
  - gas mixtures, such as SF_6/N_2 or SF_6/CF_4
  - 145kV interrupters
  - solid-state current limiter

High-GWP Gases Emission Reduction – Semiconductor Manufacture

- NF_3 remote clean technology
- C_3F_8 replacement
- Point-of-use (POU) plasma abatement system
- Thermal destruction/thermal processing units (TPU)
- Catalytic decomposition system
- Facility-wide solutions

Sources of Black Carbon Emissions in the USA



Black Carbon Emission Reduction

- Black carbon emission values are often derived from $PM_{2.5}$ estimates with some simplified assumptions.
- BC emissions are often categorized into mobile and stationary sources.
- BC is removed in the process that is mainly aimed for removal of particulate matter.

Website

Methane

Energy Sector

Natural Gas System

Transmission and storage

1. Use surge vessels for station/well venting
2. Replace high-bleed pneumatic devices with low-bleed ones
3. Replace high-bleed pneumatic devices with compressed-air
4. Reducing the glycol circulation rates in dehydrators
5. Installation of flash tank separators on dehydrators
6. Other options for methane reductions related to dehydration
7. Redesign blow-down systems and alter ESD practices
8. Portable evacuation compressor for pipeline venting
9. Installation of electric starters on compressors
10. Replace gas starters with air
11. Replace gas starters with nitrogen
12. Replace ignition/reduce false starts

Website

Non-CO_2 Greenhouse Gases: Methane

Source/Sectors: Natural Gas Systems (Production; Processing; Transmission)

Technology: Installation of electric starters on compressors

Description of the Technology:
In the United States and worldwide, many efforts have been made to identify and implement mitigation options to reduce methane emissions from the natural gas sector (USEPA, 2003). For example, the Natural Gas STAR program is a voluntary partnership between US EPA and the oil and gas industry to identify and implement cost-effective technologies and measures to reduce methane emissions. The measures to reduce methane emissions from the natural gas systems can be grouped into the following mitigation strategies: prevention, recovery and re-injection, recovery and utilization, and recovery and incineration (Hendriks & de Jager, 2001).

Small gas expansion turbine motors are often used to start internal combustion engines for compressors, generators, and pumps in natural gas production. These starters use compressed natural gas to provide the initial push to start the engine, but use of them results in methane emissions (USEPA, 2004a; IEA, 2003). Partners of the Natural Gas Star Program have found that replacing the starter expansion turbine with an electric motor starter, similar to an automobile engine starter, can avoid methane emissions. The technology may include a connection to utility electrical power, site generated power, or solar recharged batteries (USEPA, 2008).

Effectiveness: Good

Implementability: This technology is applicable in all sectors of the gas industry.

Reliability: Good

Maturity: Good

Environmental Benefits: Conversion to electric starters completely eliminates the venting and the leakage of methane through the gas shutoff valve. Partners have reported savings of 23 Mcf to 600 Mcf per year, a range that is dependent on how many times compressors are restarted in a year and how readily the engine starts up and stays running. A single startup of a properly tuned engine may require 1 Mcf to 5 Mcf of gas at 200 psig average volume tank pressure, depending on engine size (horsepower). Blowdown valves of a size and pressure differential similar to the gas shutoff valve leak up to 150 scf per hour or 1.3 MMcf per year (USEPA, 2008).

Cost Effectiveness: Methane emissions savings of 1,350 Mcf per year apply to one engine starter, ten startups per year and methane leakage through the gas shutoff valve. This technology can provide a payback in less than three years. Important economic considerations include the capital cost of installing an electric starter motor, the revenue gained from salvaging the gas expansion turbine starter, and the cost of the electric power needed to drive the motor. The electrical energy required for the new starter will be equivalent to the energy imparted by the gas expansion. Using an electrical power cost of 7.5¢ per kWh, the gas expansion turbine above is equivalent to $1 to $5 per engine start attempt, depending on engine size (horsepower) (USEPA, 2008).

- Capital Costs (including installation): $1,000 - $10,000
- Operating and Maintenance Costs (annual) : <$100
- Payback (Years): 1-3

Technology	Lifetime (yrs)	MP (%)	RE (%)	TA (%)	Capital cost	Annual cost	Benefits
Installation of electric starters on compressors[1]	10	-	75	<0.5	$838.62	$2,096	$6.82

Note: MP: market penetration; RE: reduction efficiency; TA: technical applicability; costs are in year 2000 US$/$MT_{CO2\text{-}Eq.}$
1: IEA (2003) & USEPA (2004)

Industry Acceptance Level: Fair

Limitations: Electric starters require a power supply. Power can be provided from electrical utility, portable and solar-recharged batteries, or generated onsite (USEPA, 2008).

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Clearinghouse web pages to be functional in early June, 2008

http://arb.ca.gov/cc/non-co2-clearinghouse/non-co2-clearinghouse.htm